



Armed Forces College of Medicine AFCM



Physiology of Reticular Formation & Electroencephalogram (EEG)

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INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the student will be
able to:

1. Describe the physiological significance of the reticular formation.
2. Explain the role of ARAS in consciousness.
3. List the causes of stimulation and inhibition of the RAS.
4. Mention the clinical importance of EEG.
5. Describe the different waves of EEG.



By the end of this lecture the student will be able to:

1. Part 1 (5 min) Introduction to reticular formation.

2. Part 2 (35 min) main lecture

- ✓ Types of neurons in RF.
- ✓ Functions of RF.
- ✓ Factors affecting activity of ARAS.
- ✓ Different waves of EEG.

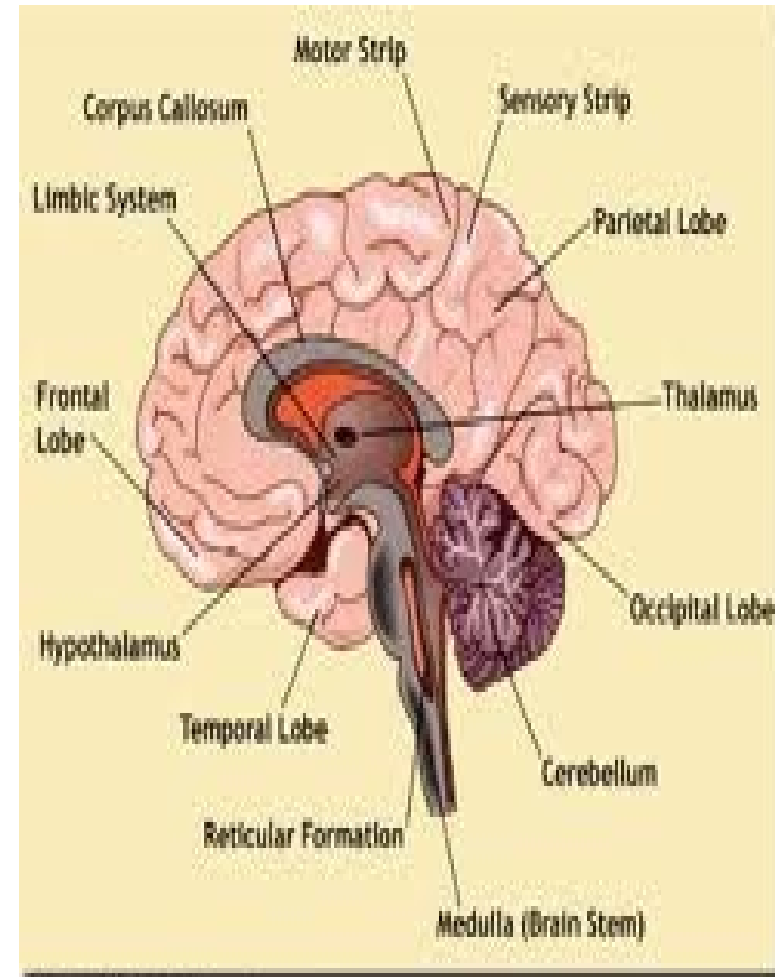
3. Part 3 (5 min) Summary

Reticular formation



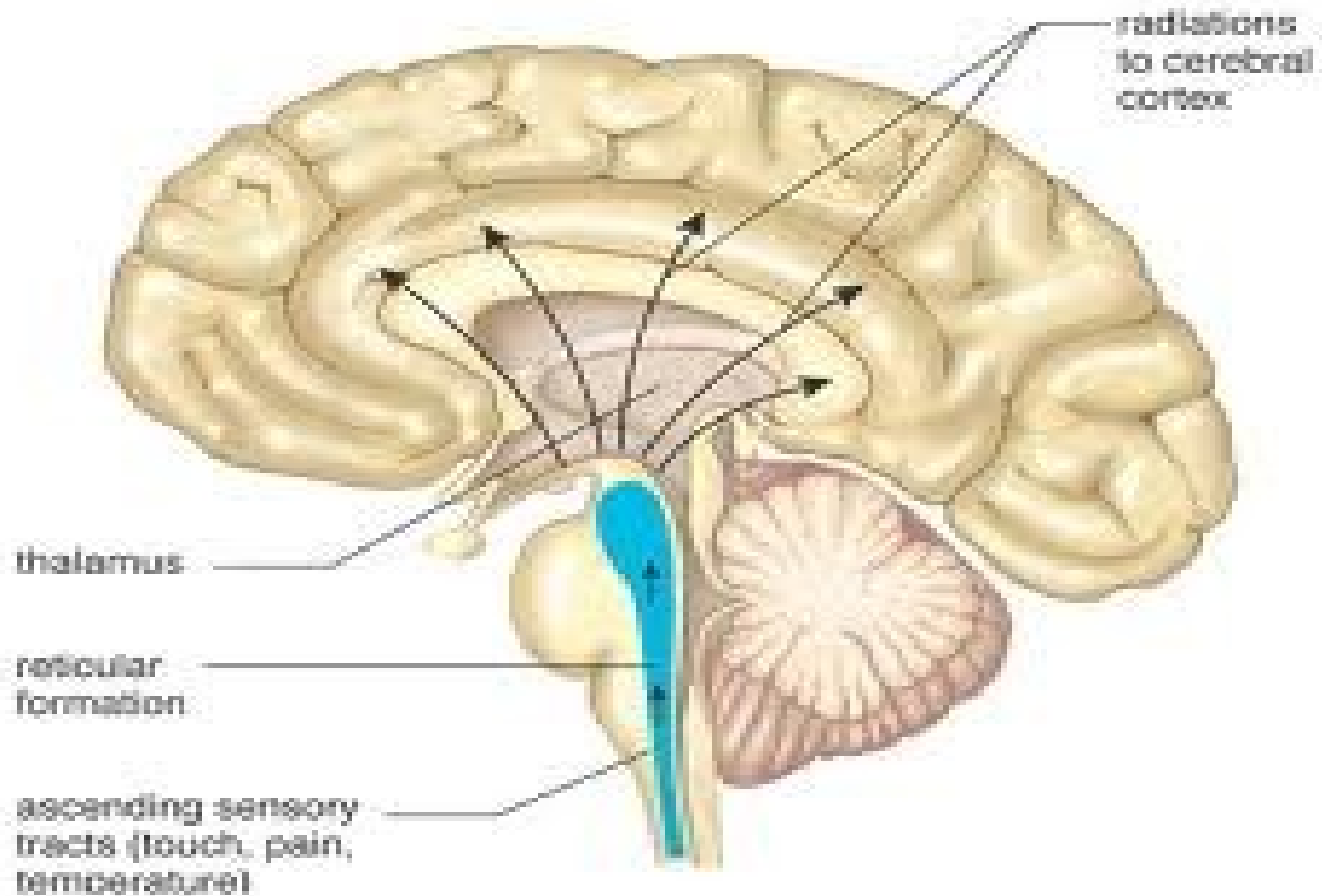
Def:

- A network of neurons located in the brain stem.
(midventral portion of the medulla and midbrain)
- It contains a sensory part and a motor part performing different functions.



Brief Brain Anatomy

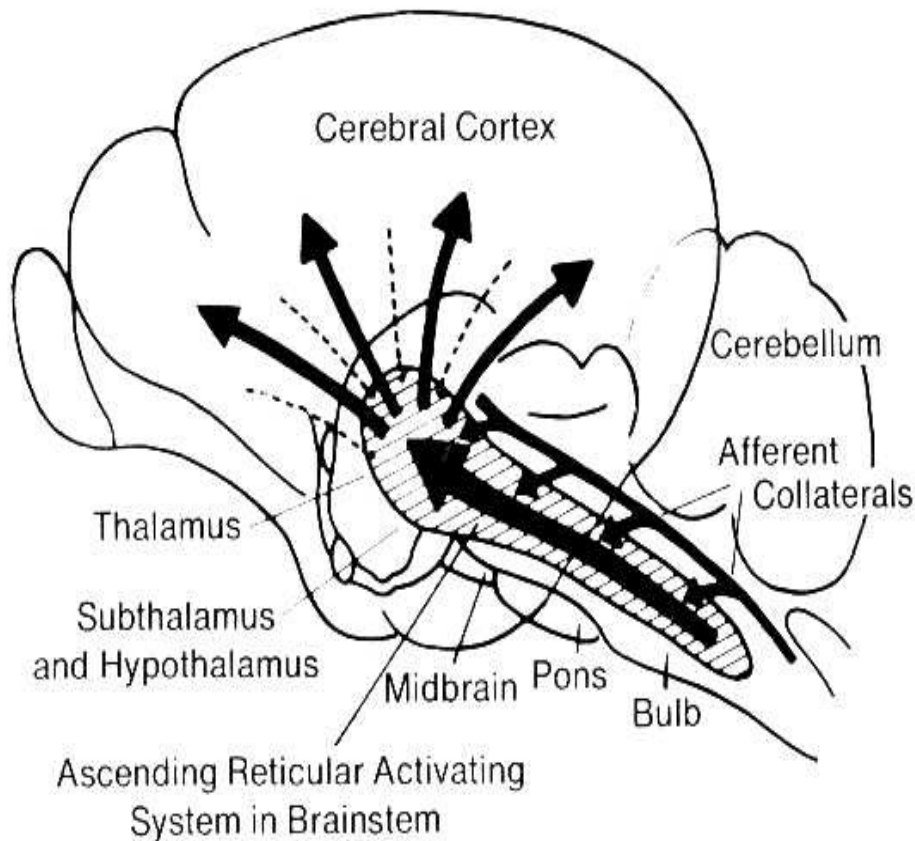
Reticular formation



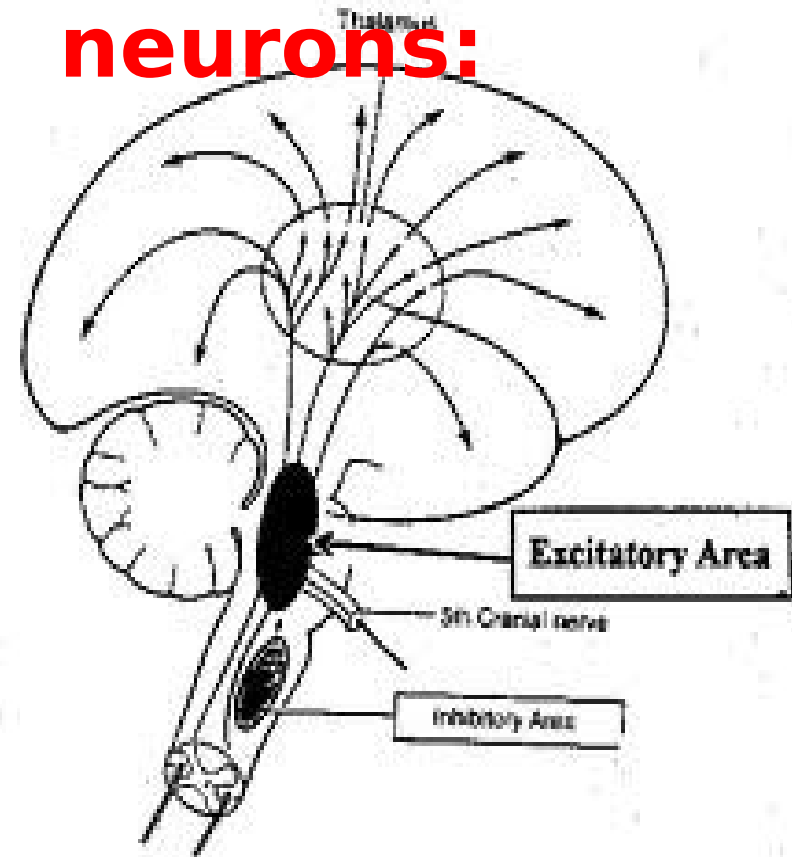
Reticular formation

Cells in the reticular formation are:

1- Sensory

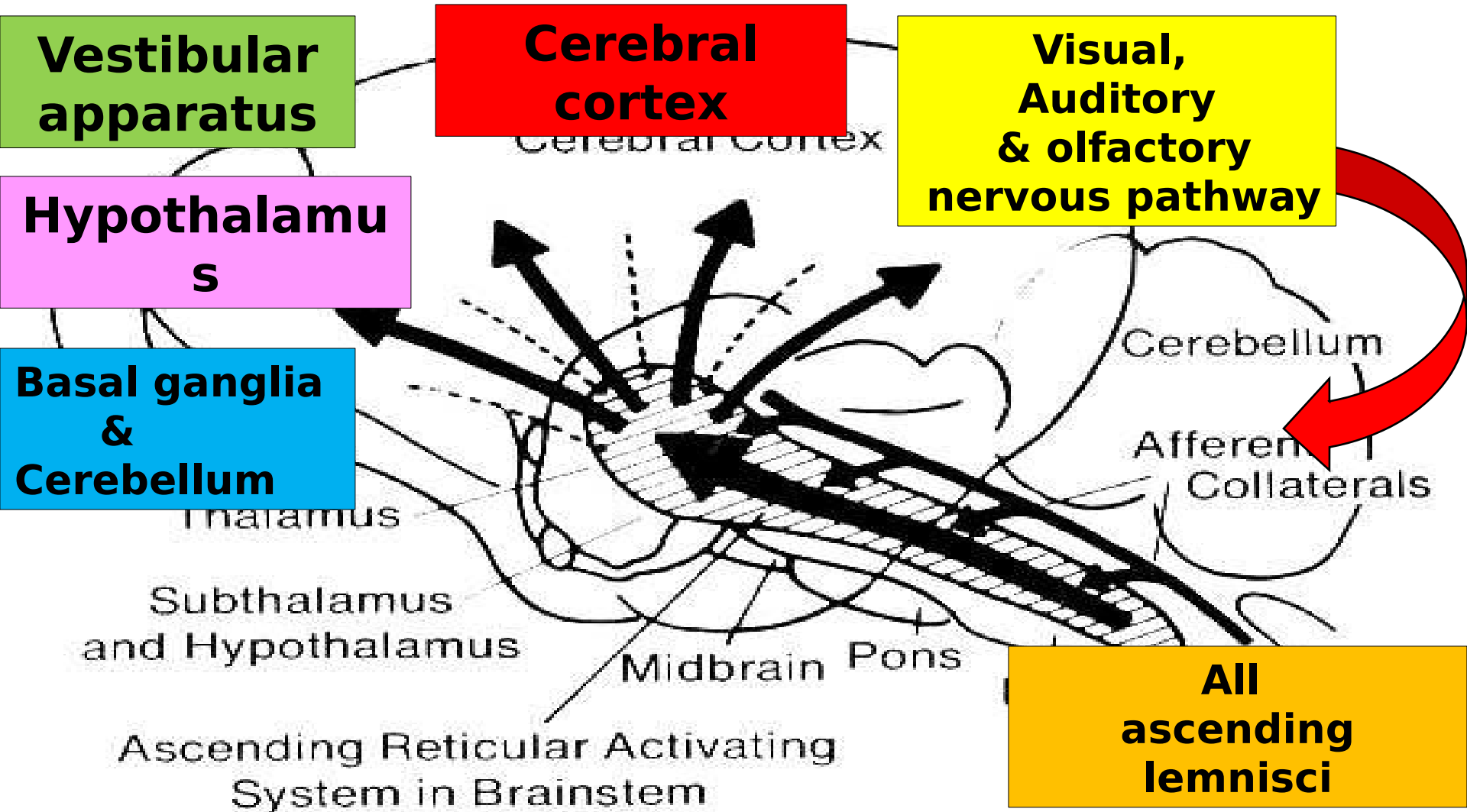


2- Motor neurons:



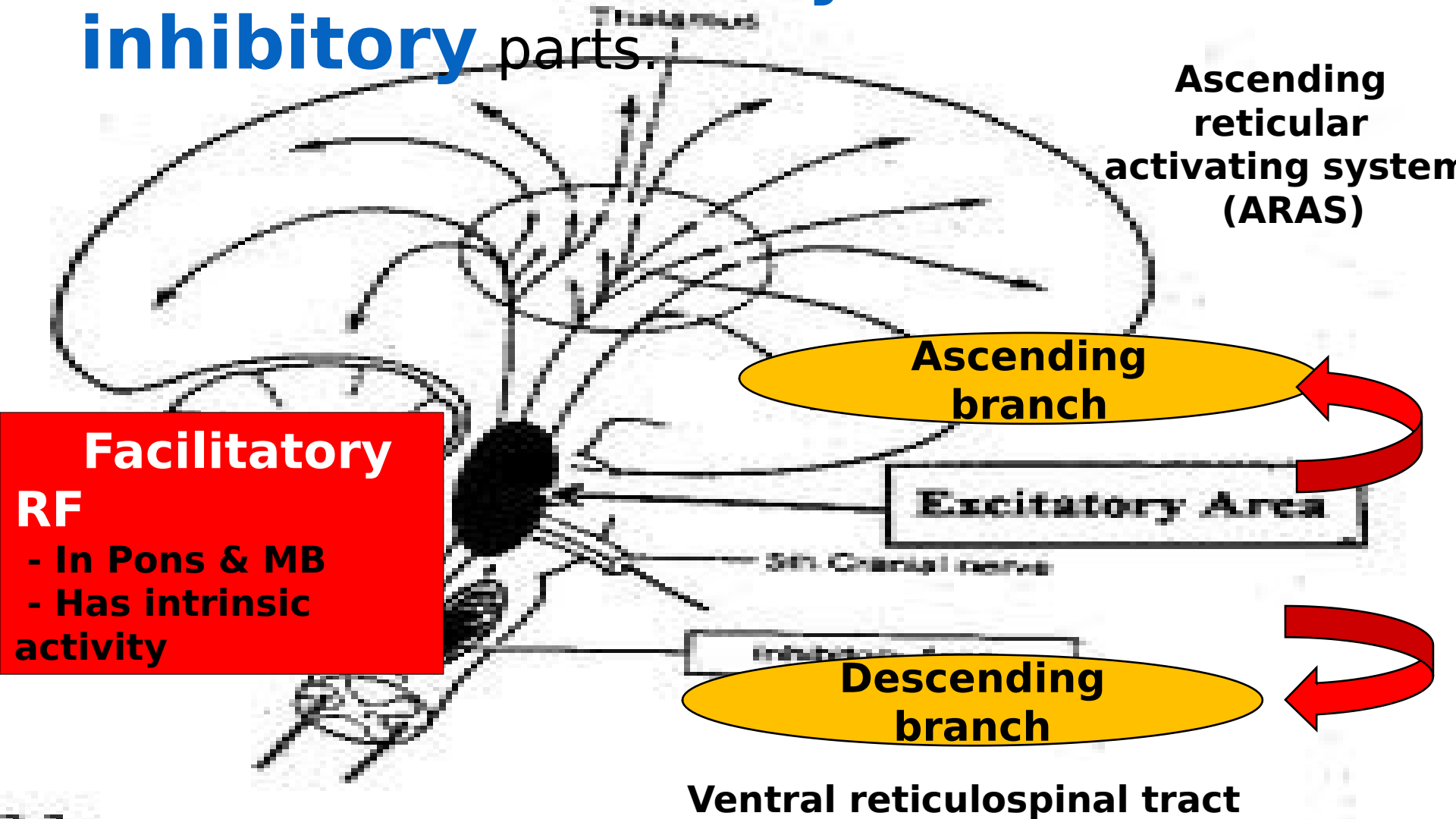
Sensory neurons of RF

- ✓ They receive afferent impulses from:

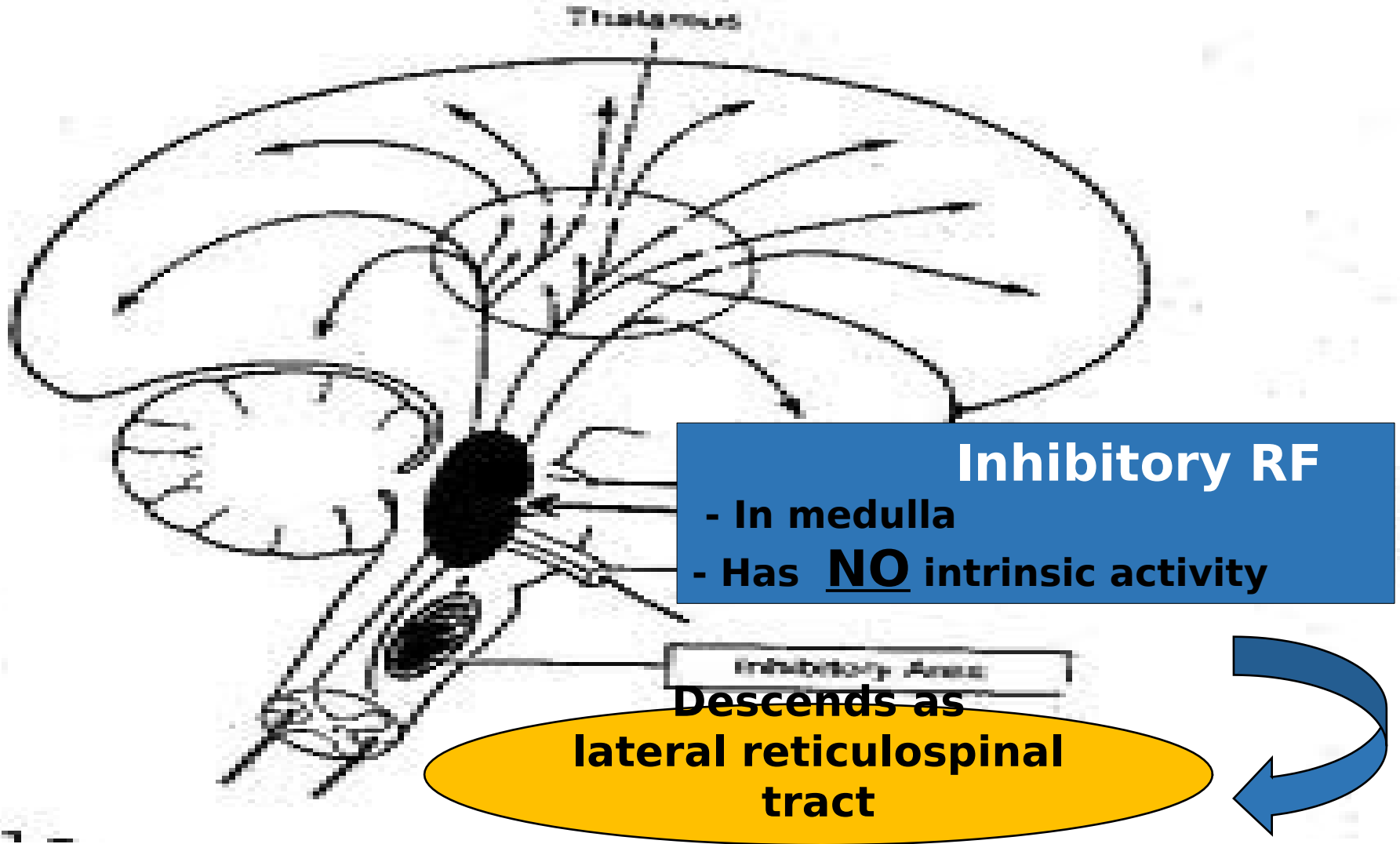


Motor neurons of RF

- ✓ It contains **facilitatory** & **inhibitory** parts.



Motor neurons of RF



Facilitatory Reticular Formation



- ✓ Present in the pons & midbrain.
- ✓ It has an *intrinsic activity*.
- ✓ **Ascending branch** discharges excitatory impulses to all areas of cerebral cortex through **ascending reticular activating system** which is responsible for arousal (awaking).
- ✓ **Descending branch** discharges *excitatory* impulses to spinal motor neurons through **ventral** reticulospinal tract.



The activity of facilitatory RF is:

✓ ↑ed by impulses from:

- Area 4.
- Neocerebellum.
- Vestibular nucleus.
- Basal ganglia
(*caudate*)

✓ ↓ed by impulses from:

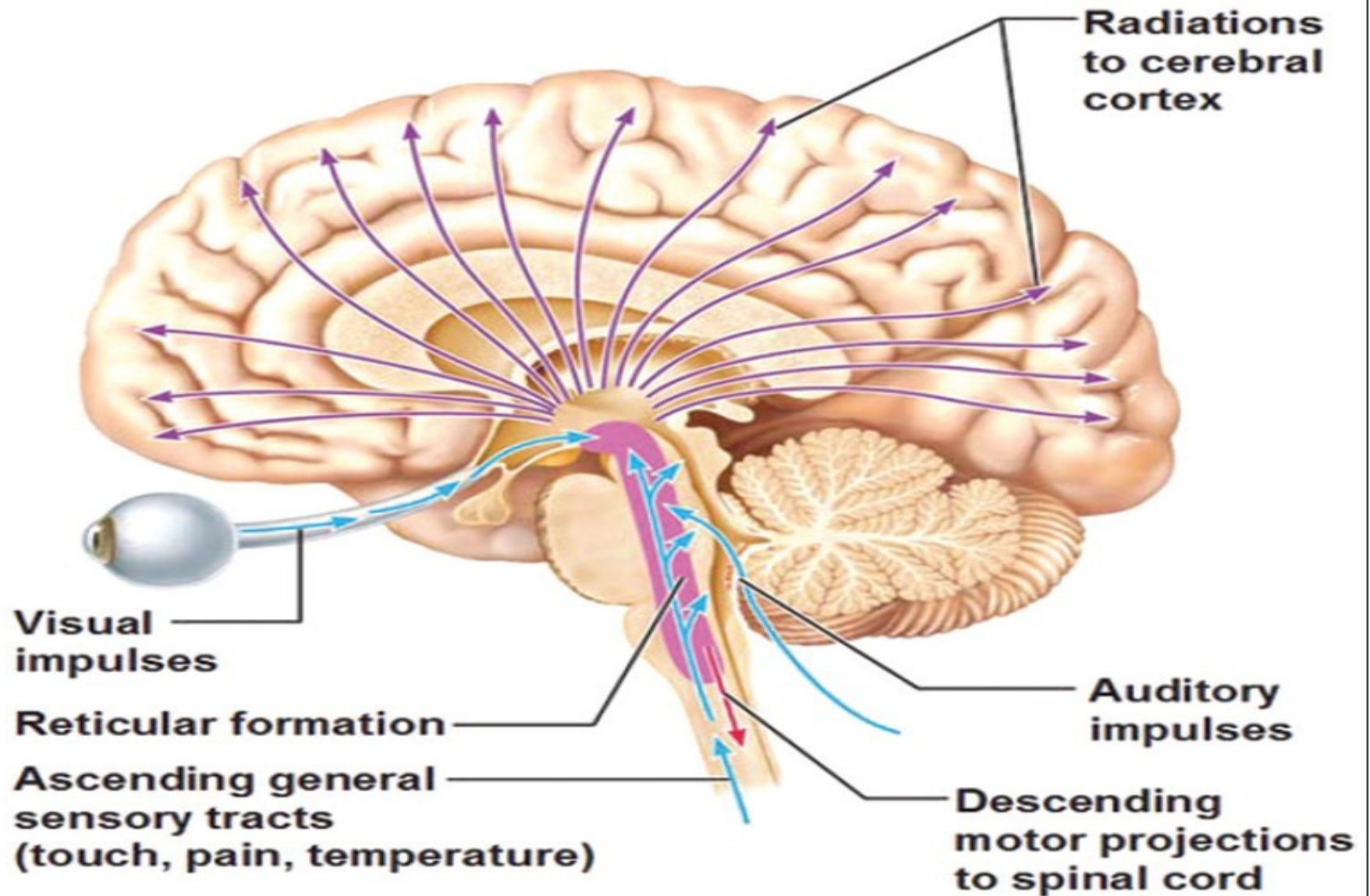
-
- Area 6.
- Paleocerebellum.
- Red nucleus.
- Basal ganglia
(*putamen*)

Inhibitory Reticular Formation



- ✓ Present in the medulla oblongata.
- ✓ It has **NO** intrinsic activity.
- ✓ It sends *inhibitory* impulses to the spinal motor neurons through *lateral* reticulospinal tract.
- ✓ **Its activity is (+) by impulses from:**
 - Area 6.
 - Paleocerebellum.
 - Basal ganglia (putamen)
 - Red nucleus.

The Reticular Formation

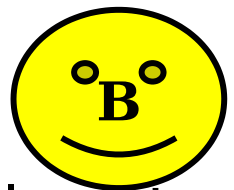


Quiz (1) on:

Which of the following is incorrect about r
Types of neurons in RF
formation?



- a) Its excitatory part locates mainly in the pontine region.
- b) Its inhibitory part located mainly in the medulla oblongata and send inhibitory impulses to all cortical areas.
- c) Its excitatory part gives origin to the reticular activating system
- d) Its excitatory part discharges stimulatory impulses to both cerebral cortex and A.H.Cs of the spinal cord.



Functions of Reticular Formation



- 1- It is a link between higher centers in the brain and lower centers in the spinal cord □ *integration*.
- 2- Control the level of consciousness & alertness and regulation of sleep wake cycles through projections to the thalamus & cortex called *the reticular activating system (RAS)*.
- 3- RAS is concerned with electrical activity of the brain (*EEG*).
- 4- Regulation of *autonomic functions* as it contains vital centers e.g cardiac and vasomotor centers, as well as the respiratory centers. It also contains neurons that regulate

Functions of Reticular Formation



5- Regulation of **stretch reflex & muscle tone** via reticulospinal tracts.

e.g During standing, there are continuous facilitatory impulses passing from the RF & VN to spinal motor neurons \square \uparrow muscle tone in extensors \square to support the body.

6- Site of perception of **slow pain**. It is also involved in modulation of nociceptive sensations to the cerebral cortex as the periaqueductal grey area (**PAG**) & the **raphe nucleus** are part of pain control analgesia system & their serotonergic neurons synapse with pain inhibitory complex (PIC) in spinal cord to block pain transmission.

1. Facilitatory impulses from the RF to neurons of the spinal cord increase during standing.

Quiz (2) on: Functions of RF



(True)

2. RF is the site of perception & localization of fast pain.

(False)

3. Serotonergic neurons from raphe nucleus block pain transmission in spinal cord.

(True)

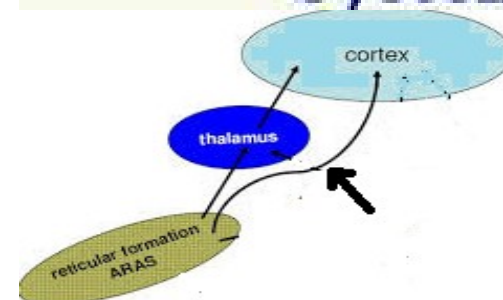
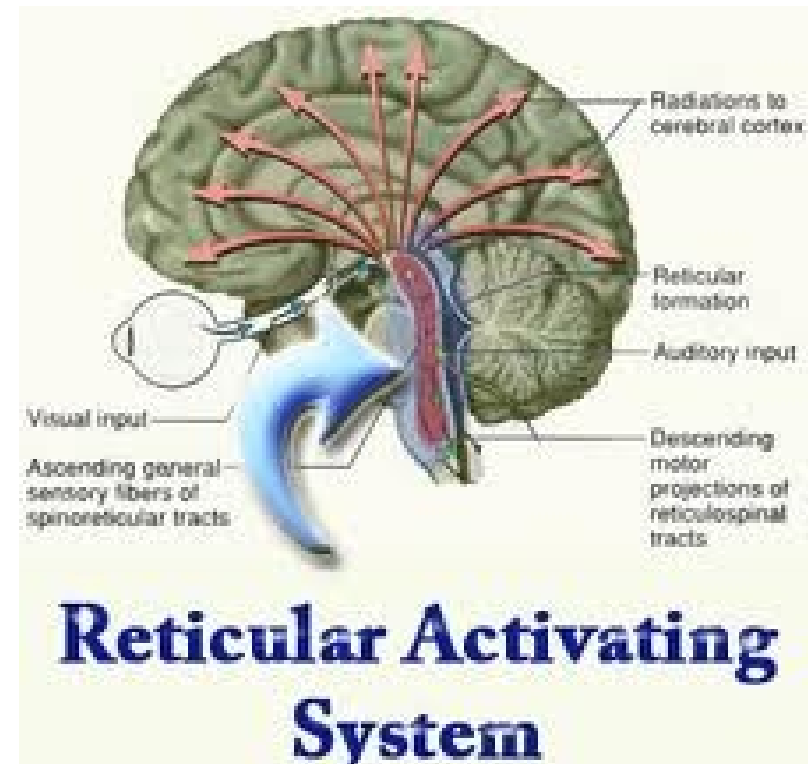
4. RF excites all parts of the cortex through the ARAS.

(True)

Ascending Reticular Activating System (ARAS)

- ✓ It is a complex polysynaptic pathway,
 - ✓ originates at the facilitatory RF.
- NSTN in thalamus.
- projects to almost all areas of cerebral cortex.

(Reticulo-thalamo-cortical pathway)

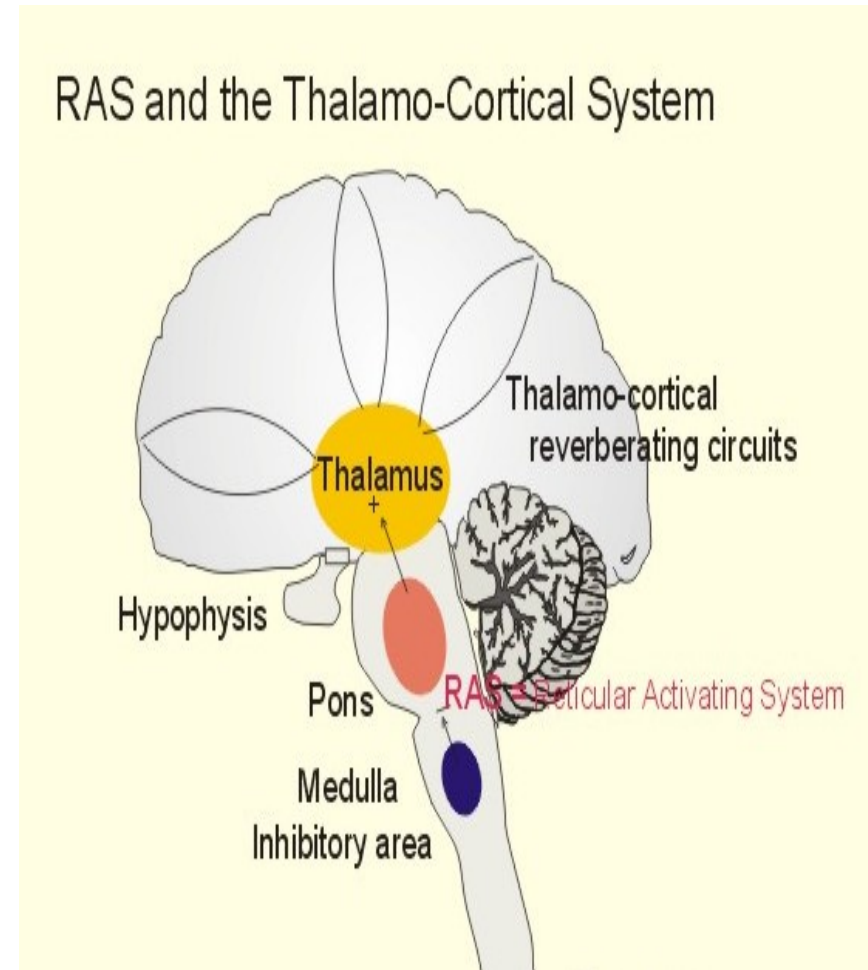


Reticulo-thalamo-cortical pathway

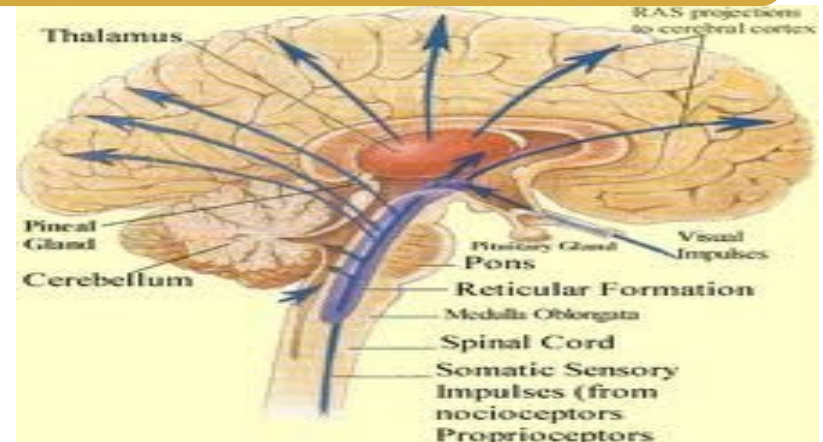
Ascending Reticular Activating System (ARAS)

Function of ARAS:

- ✓ Concerned with consciousness & production of alert response.
- It discharges to the thalamus & cortex to potentiate thalamic and cortical activity.
- It helps transitions from relaxed wakefulness to periods of high attention & alertness.

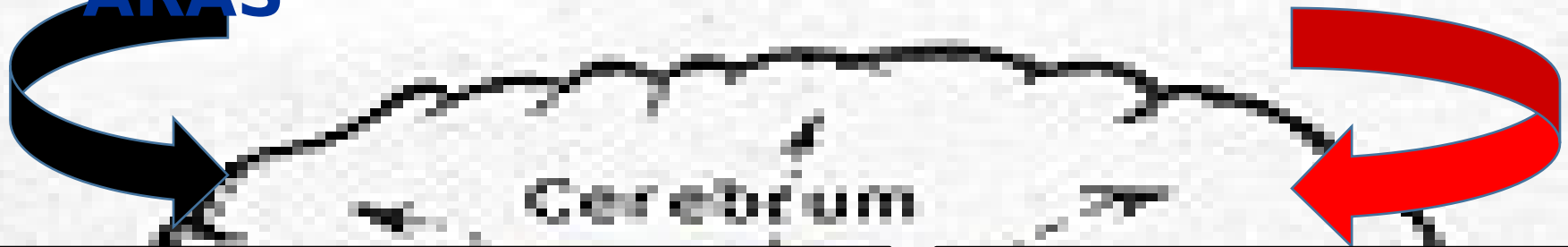


Consciousness *(Wakefulness)*



- ✓ It is the awareness of both self & one's surroundings, thoughts and feelings.
- ✓ **Produced** by general excitation of the cerebral cortex as a result of activation of ARAS. **RF** \square **NSTN** \square **generalized (+) cerebral cortex**
(*Reticulo-thalamo-cortical pathway*)
- ✓ **Maintained** by +ve feedback mechanism through re-excitation of ARAS by signals from the activated cerebral cortex. **Cerebral cortex** \square **NSTN** \square **RF**
(*Cortico-thalamo-reticular pathway*)

Factors affecting the activity of ARAS

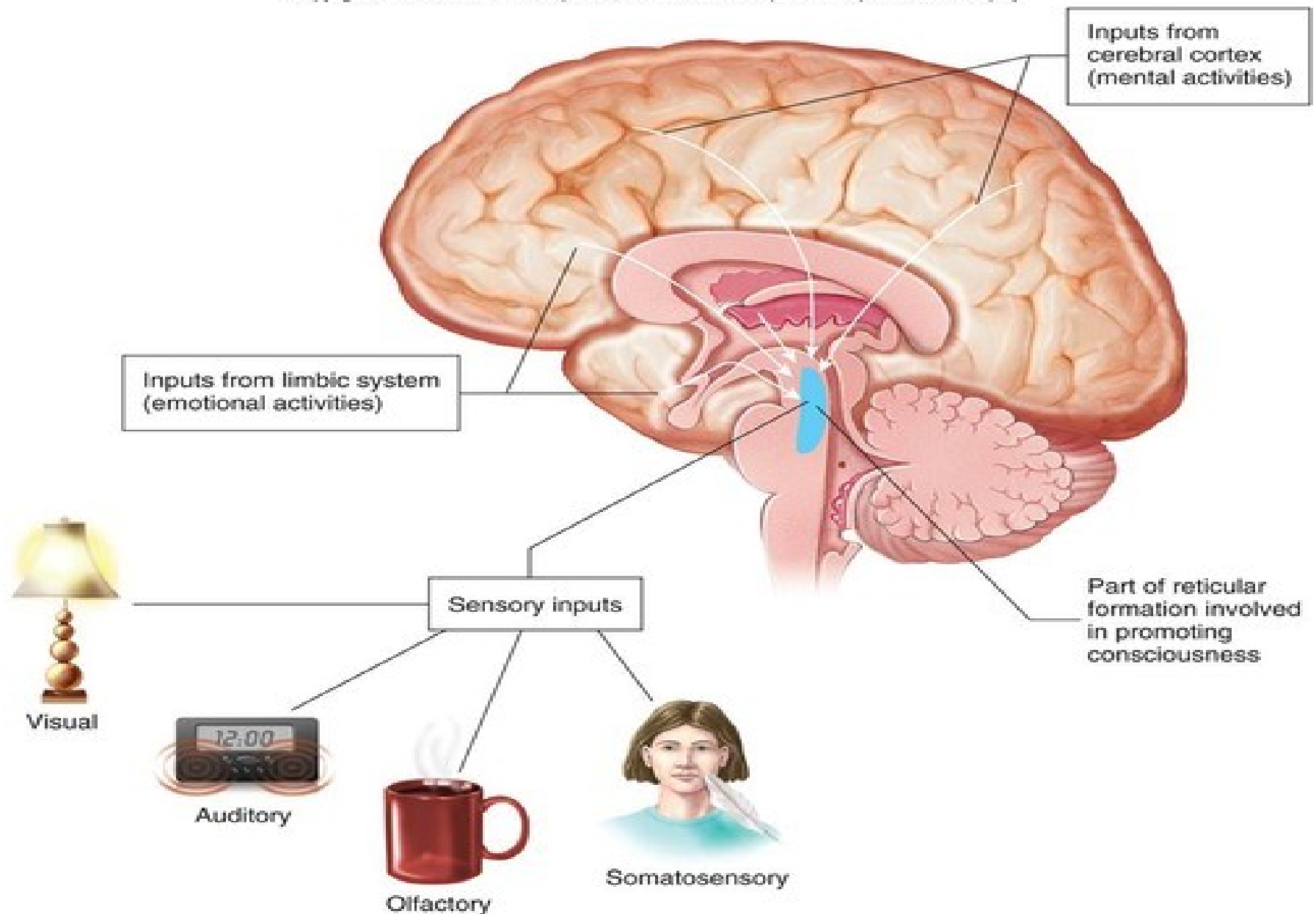


(↑ ↑)

- 1- Sensory signals (e.g pain)
- 2- Signals from cerebral cortex & hypothalamus (e.g voluntary movements & during emotions)

(↓ ↓)

- 1- ↓ signals from sensory pathways or cerebral cortex
- 2- Stimulation of sleep



Quiz (3) on:

Factors affecting activity of ARAS



✓ ----- refers to subjective awareness of surroundings and self
Consciousness/wakefulness

✓ Sensory signals as ----- stimulate the activity of ARAS while stimulation of ----- centers inhibits its activity .
Pain , sleep

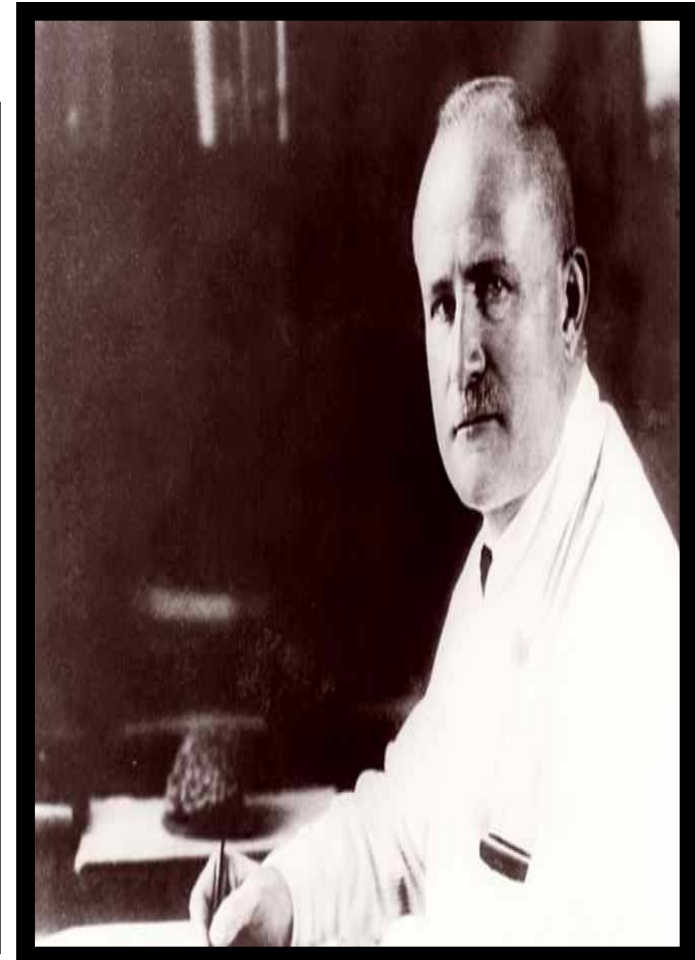
Electroencephalogram (EEG)



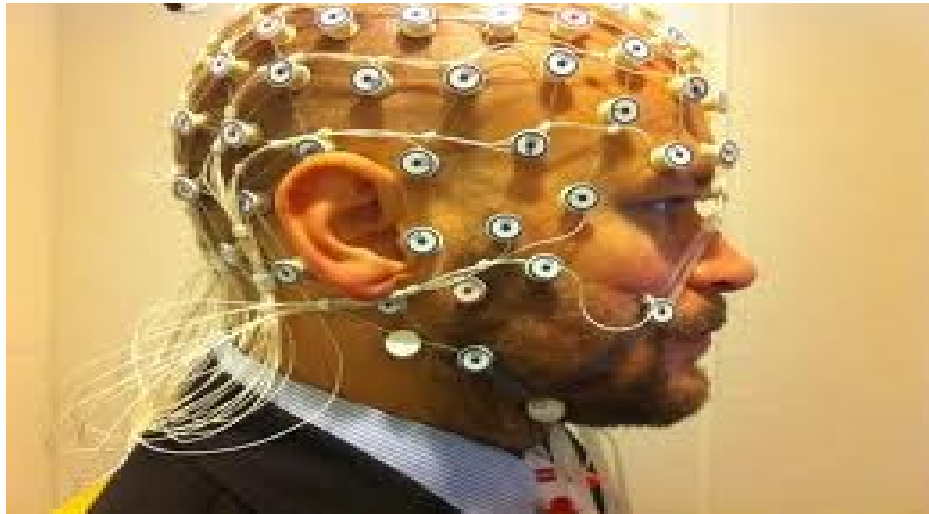
Def:

✓ Recording of **spontaneous** electrical activity of the brain in **unanaesthetized** subjects by applying electrodes to the scalp of the patient.

✓ **Hans berger**, is the German psychiatrist who recorded the first human EEG in 1924.



Electroencephalogram (EEG)



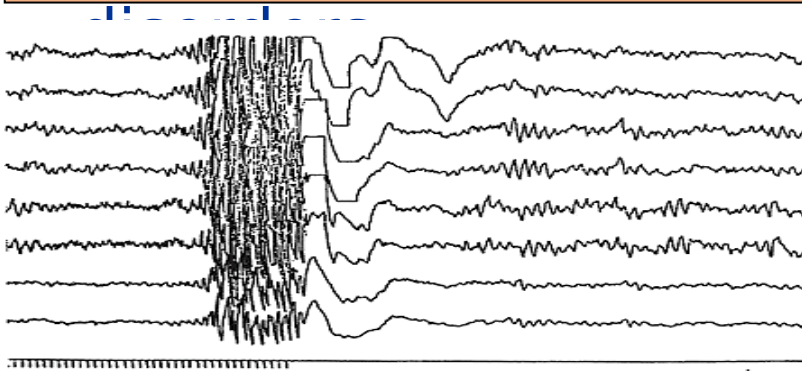
<https://www.nawinna.com/services/view-details/19/eeg-unit-at-nawinna-medicare-hospitals>

Electroencephalogram (EEG)

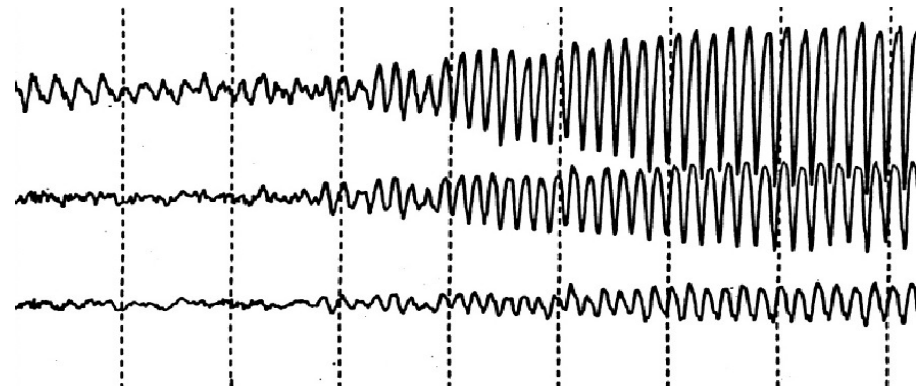


✓ **It is used in:**

1. Localization of brain tumors.
2. Diagnosis of epilepsy.
3. Localization of collection of fluid overlying the cerebral cortex (subdural hematoma).
4. Monitor of sleep stages & diagnosis of sleep



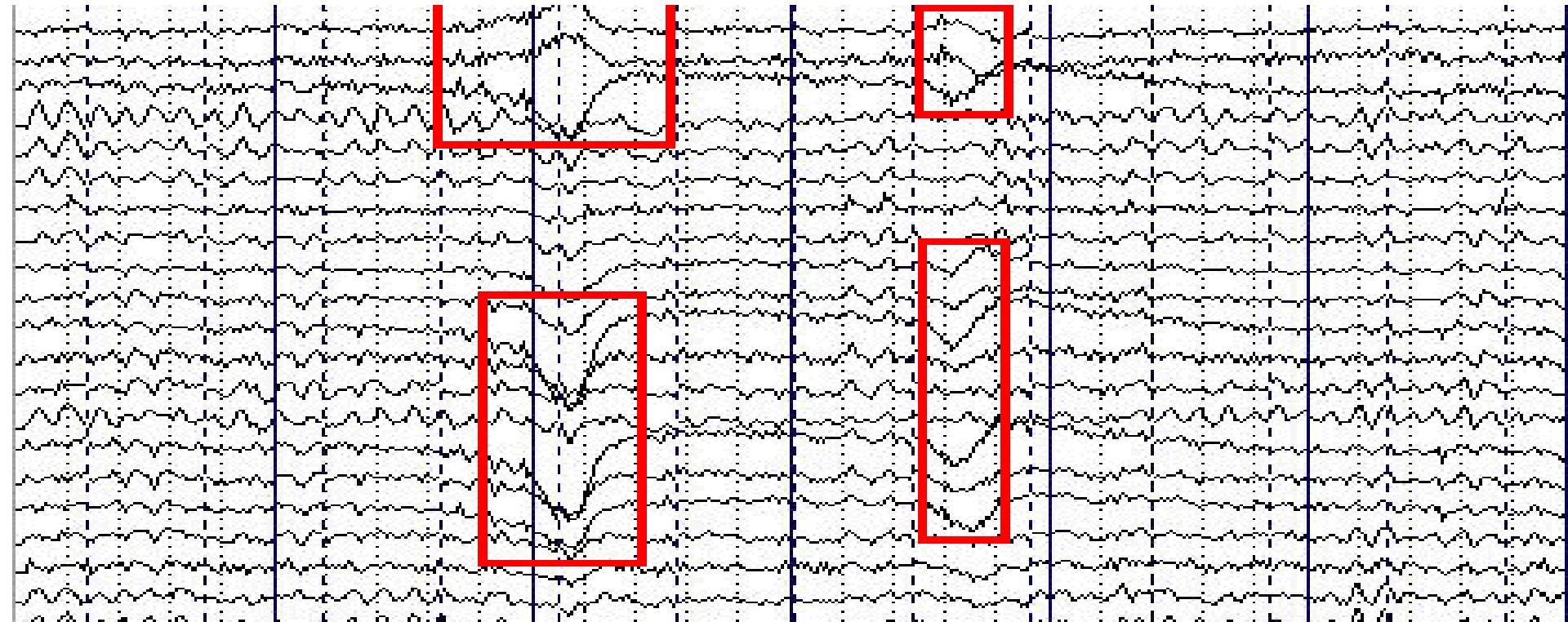
<https://mayfieldclinic.com/pe-eeeg.htm>



EEG in Epilepsy

(Sharp high voltage waves or spikes)

Electroencephalogram (EEG)



<http://www.cerebromente.org.br/n03/tecnologia/eeg.htm>

EEG in case of brain tumor

(Distorted irregular waves)

EEG Waves



Consist of 4 waves

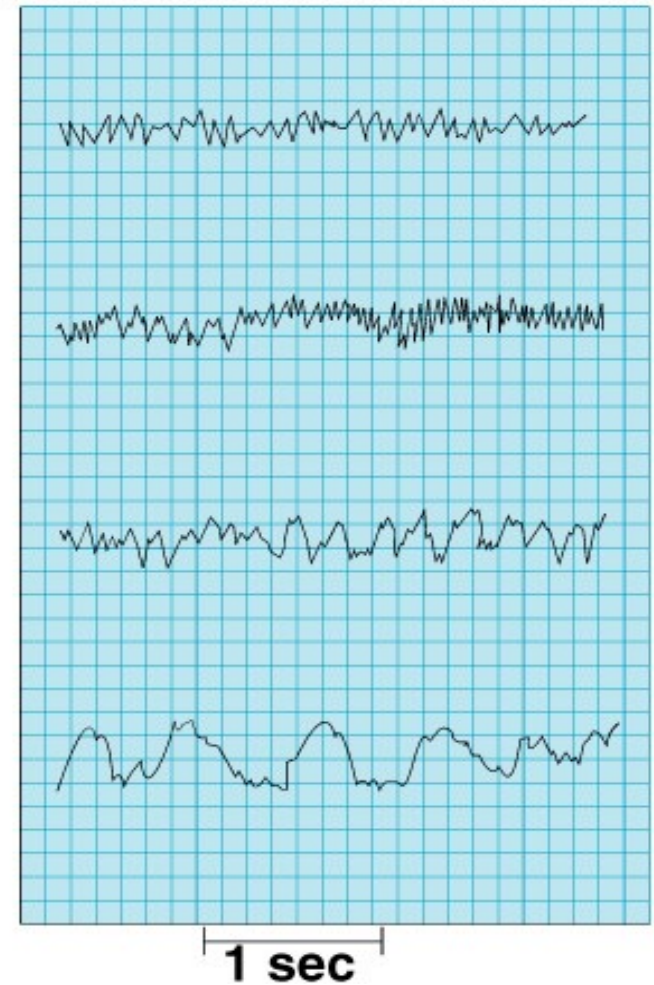
- (Alpha)
- (Beta)
- (Theta)
- (Delta)

Alpha

Beta

Theta

Delta



Important

EEG Waves



• Alpha:

- Recorded from parietal and occipital regions.
- Adult, awake, relaxed, with eyes closed.
- 8 -13 cycles/sec.
- 50 microvolt.

• Beta:

- Recorded from frontal region.
- Adult awake with eyes opened (during brain activity) & infants.
- 18-30 cycles/sec.
- 10-25 microvolt.

• Theta:

- Recorded from temporal and parietal lobes.
- children and adults during light sleep & emotional stress.
- 4-7 cycles/sec.
- 100 microvolt.

• Delta:




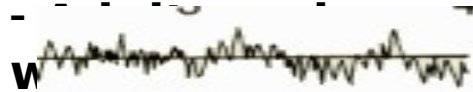
Recorded from all cortical areas.

Recorded in deep sleep, infants & brain damage.

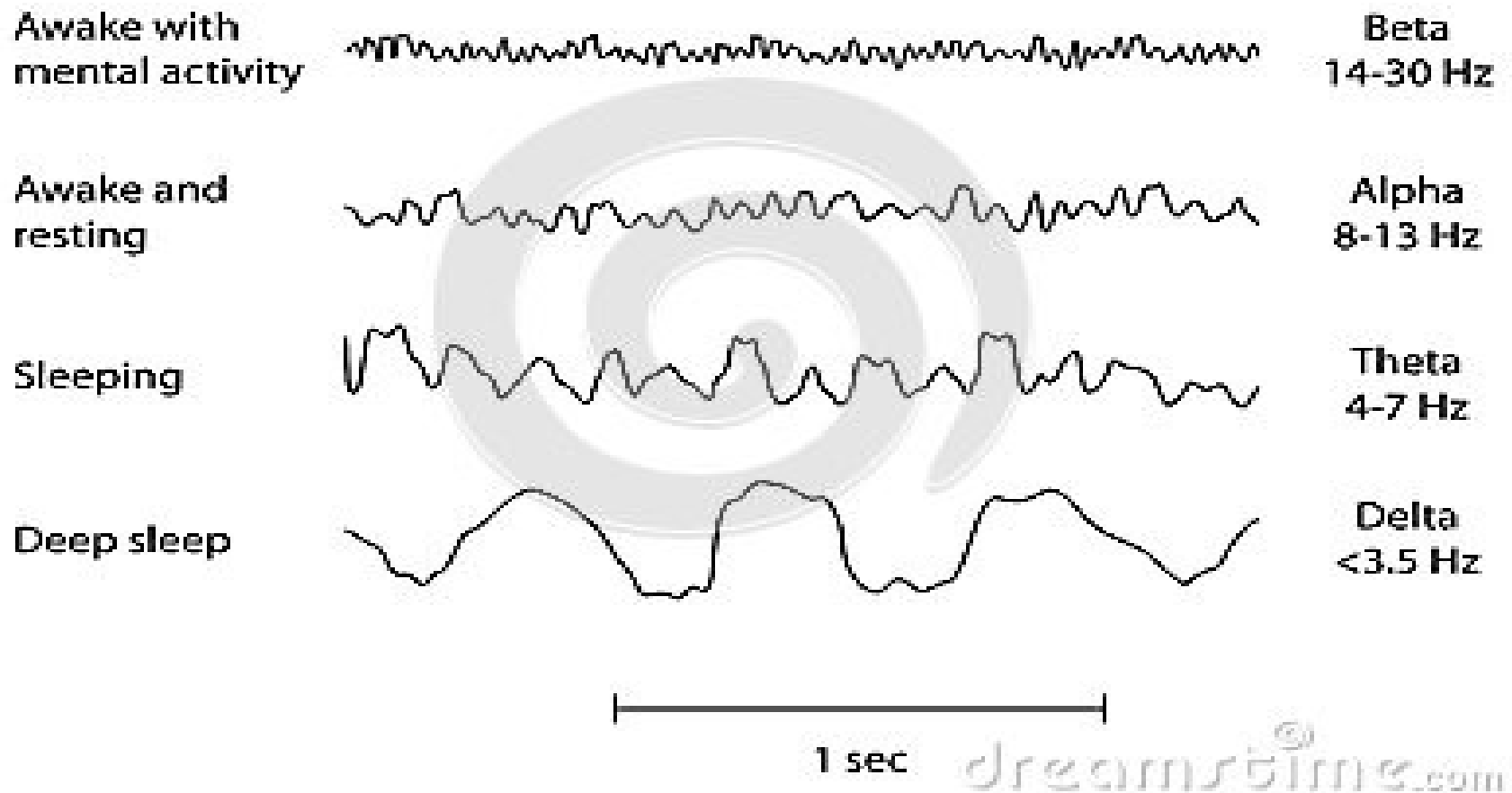
0.5-4 cycles/sec.
100 microvolt.

EEG Waves



Condition of recording	Site of recording	Frequency (Hz)	Amplitude (μv)	Waves
 Brain Damage.	Delta All cortical areas	0.5-4	100	Delta
 - Emotional stress.	Theta Temporal & parietal region	4-7	100	Theta
 with eyes closed	Alpha Temporal & parietal region	8-13	50	Alpha
 eyes opened (during brain activity) Infants	Beta Frontal region	18-30	25	Beta

Normal Adult Brain Waves



https://www.123rf.com/photo_18111272_normal-brain-waves-eeg.html

What is alpha block?



- ✓ It is an EEG response that occurs when the subject become alert (*e.g any sensory stimulation or mental concentration*).
- ✓ The **alpha** rhythm is replaced by a fast irregular low-voltage **beta** rhythm.
- ✓ This EEG response is called the ***arousal or alerting response***.
- ✓ It is due to stimulation of ascending reticular activating system (ARAS).

Quiz (4) on:

Different waves of EEG.



- ✓ The EEG wave recorded brain activity is -----, while the EEG observed during deep sleep is -----

Beta wave/Delta wave

- ✓ Theta wave has an amplitude of ----- and its frequency is ----- and recorded mainly during -----

100 μ v/ 4-7 Hz/ light sleep & stress

SHORT SUMMARY!

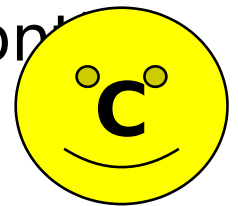
- ✓ **Reticular formation** is a network of neurons that has both sensory and motor neurons
- ✓ **Facilitatory reticular formation** in the pons & midbrain has intrinsic activity, it discharges excitatory impulses to all areas of cerebral cortex through ascending reticular activating system (ARAS) and its descending ventral reticulospinal tract exerts a facilitatory effect on spinal gamma motor neurons.
- ✓ **Inhibitory reticular formation** in medulla has no intrinsic activity, it sends inhibitory impulses to the motor neurons of spinal cord through lateral reticulospinal tract.
- ✓ It contains vital centers e.g cardiac, vasomotor &, respiratory centers, concerned with regulation of muscle tone, control of consciousness & it is the site of perception of slow pain..
- ✓ Its activity is **increased** by signals from the cerebral cortex e.g. during emotion & voluntary movement and drugs e.g. catecholamines & caffeine. While, reduction of signals from the sensory pathways or the cerebral cortex, stimulation of the sleep centers & general anesthetic drugs **decrease** its activity.
- ✓ EEG is the recording of spontaneous electrical activity of the brain in unanesthetized person composed of 4 main waves, alpha, beta, theta & delta. Each wave is recorded under certain conditions and in specific brain areas.

Lecture Quiz



Which of the following is true about the reticular activating system?

- a) Its neurons are located mainly in the midbrain.
- b) Its neurons can be inhibited by impulses from cerebral cortex during voluntary movement.
- c) Its neurons can be activated by sensory signals from proprioceptors.
- d) Its neurons are the descending branches of pontine reticular formation.

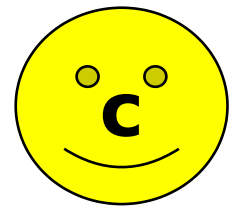


Lecture Quiz



In a healthy, awake adult sitting with the eyes closed, the dominant EEG rhythm observed with electrodes over the occipital lobes is:

- a. Delta (0.5-4 Hz)
- b. Theta (4-7 Hz).
- c. Alpha (8-13 Hz)
- d. Beta (18-30 Hz)
- e. Fast irregular low voltage activity.



SUGGESTED TEXTBOOKS



1. Ganong's Review of Medical Physiology. 23rd edition , chapter 14 (pages 627: 631) & chapter 15, page 229.
2. Guyton & Hall: Textbook of Medical Physiology, 12e. (XI), Nervous system (Motor & Integrative functions) page 1330-1333



Thank You